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(54) IGNITION MATERIAL FOR AN IGNITER

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(52) **U.S. Cl.** **102/202.5**; 149/19.8; 149/45
(58) **Field of Search** 102/202.5; 149/19.8, 149/45

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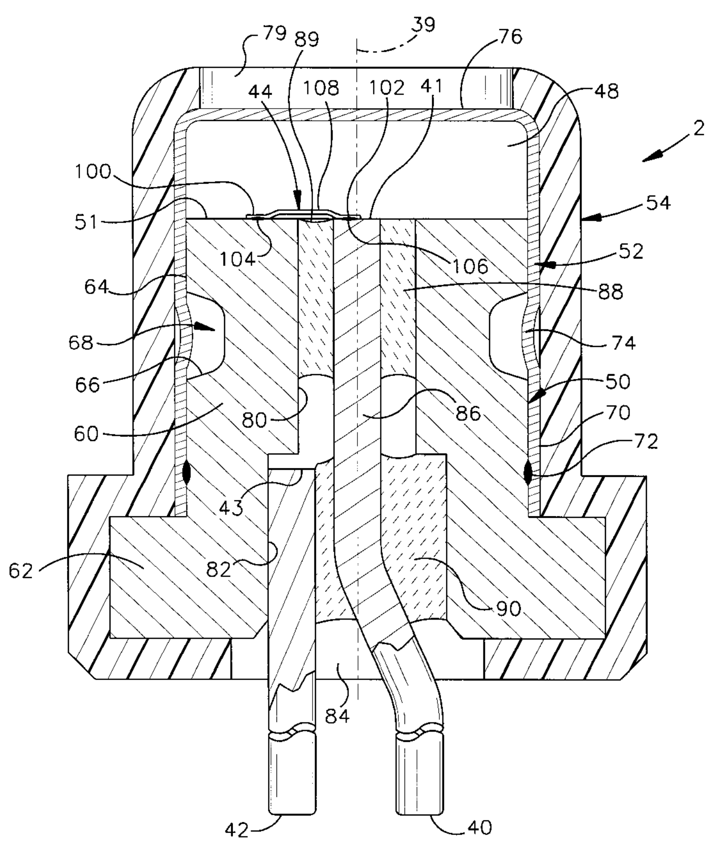
(57) ABSTRACT

An electrically actuatable igniter **(24)** comprises a pair of electrodes **(40)** and **(42)**. A heating element **(44)** is electrically connected between the electrodes **(40)** and **(42)**. An ignition material **(48)** is in contact with the heating element **(44)**. The ignition material **(48)** includes an energetic composition. The energetic composition comprises, by weight of the energetic composition, about 60% to about 90% basic copper nitrate, up to about 20% supplemental oxidizer, about 5% to about 20% charcoal, and up to about 10% supplemental fuel.

9 Claims, 1 Drawing Sheet



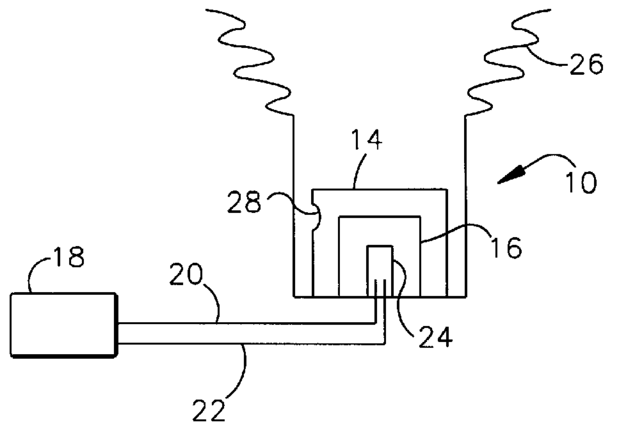

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Fig.1

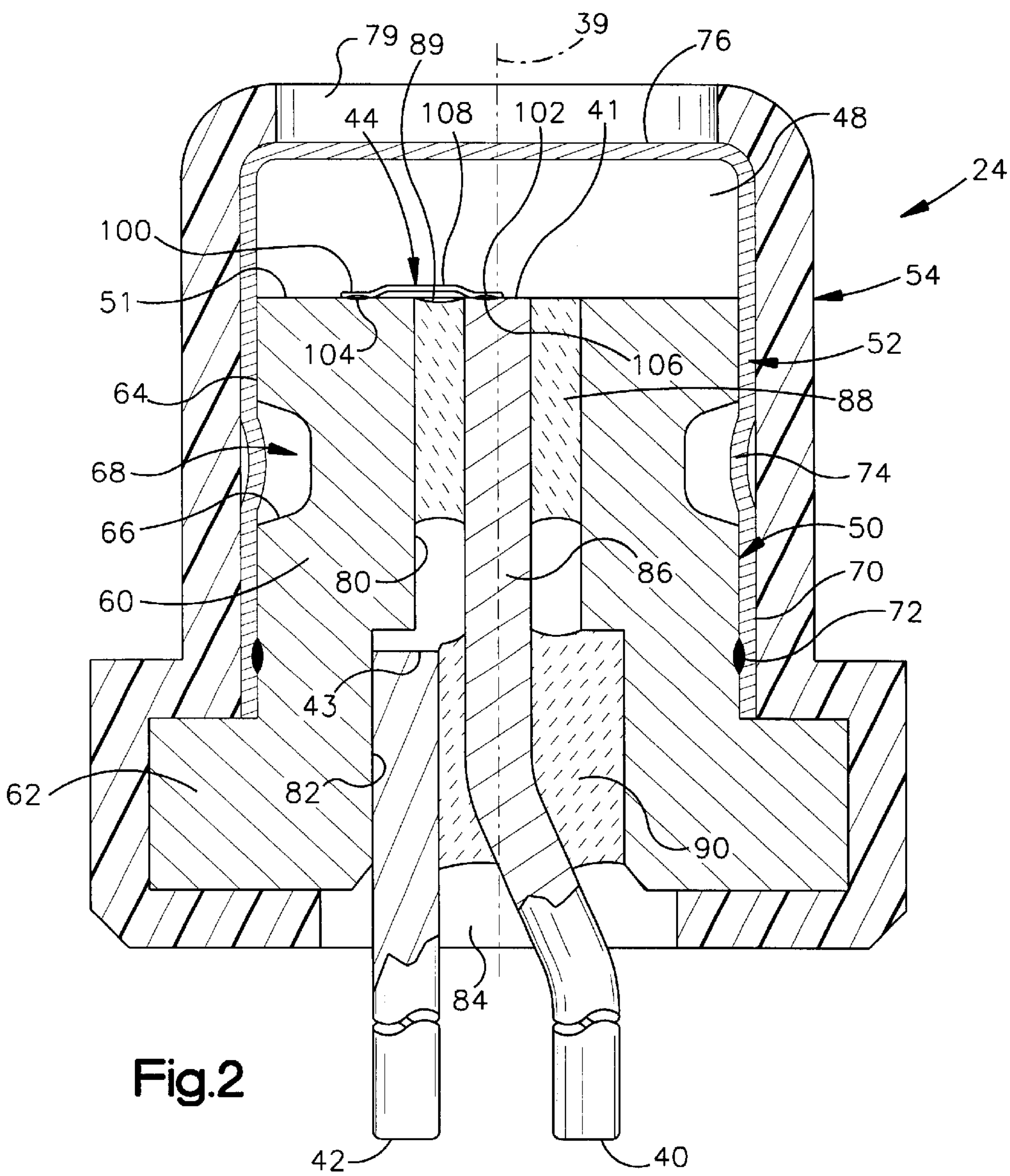
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Fig.2

IGNITION MATERIAL FOR AN IGNITER

FIELD OF THE INVENTION

The present invention relates to an igniter, and particularly relates to an ignition material for an igniter for actuating an inflatable vehicle occupant protection apparatus.

BACKGROUND OF THE INVENTION

An inflatable vehicle occupant protection device, such as an air bag, is inflated by inflation gas provided by an inflator. The inflator typically contains ignitable gas generating material. The inflator further includes an igniter to ignite the gas generating material.

The igniter contains a charge of ignition material. The igniter also contains a bridgewire that is supported in a heat transferring relationship with the ignition material. When the igniter is actuated, an actuating level of electric current is directed through the bridgewire in the igniter. This causes the bridgewire to become resistively heated sufficiently to ignite the ignition material. The ignition material then produces ignition products that, in turn, ignite the gas generating material.

An example of an ignition material typically used for igniting a gas generating material is black powder. Black powder is composed of sulfur, charcoal, and potassium nitrate or sodium nitrate. Black powder has several drawbacks when used as an ignition material for igniting a gas generating material. There are restrictions on shipping black powder, and special precautions must be taken when manufacturing black powder. Moreover, black powder is not a completely satisfactory ignition material for LOVA gas generating materials or propellants because it is not sufficiently energetic to ignite the LOVA gas generating materials or propellants. Black powder also does not exhibit low vulnerability characteristics, such as resistance to thermal decomposition and ignition upon shock. Accordingly, it would be desirable to provide an ignition material that is a substitute for black powder and that would be more energetic than black powder as an ignition material, while at the same time exhibiting less vulnerability to thermal decomposition and ignition upon shock.

SUMMARY OF THE INVENTION

The present invention is an electrically actuatable igniter. The electrically actuatable igniter comprises a pair of electrodes. A heating element is electrically connected between said electrodes. An ignition material is in contact with the heating element. The ignition material includes an energetic composition. The energetic composition comprises, by weight of the energetic composition, about 60% to about 90% basic copper nitrate, up to about 20% supplemental oxidizer, about 5% to about 20% charcoal, and up to about 10% supplemental fuel.

The present invention is also directed to an energetic composition that comprises, by weight of the energetic composition about 65% to about 85% basic copper nitrate, up to about 10% supplemental oxidizer, about 10% to about 15% charcoal, and up to about 10% supplemental fuel.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other features of the invention will become more apparent to one skilled in the art upon consideration of the following description of the invention and the accompanying drawings, in which:

FIG. **1** is a schematic view of a vehicle occupant protection apparatus embodying the present invention; and

FIG. **2** is an enlarged sectional view of a part of the apparatus of FIG. **1**.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. **1**, an apparatus **10** embodying the present invention includes an inflator **14** and an inflatable vehicle occupant protection device **26**. The inflator **14** contains a gas generating material **16**. The gas generating material **16** is ignited by an igniter **24** operatively associated with the gas generating material **16**. The igniter **24** is connected by electric leads **20** and **22** in an electric circuit that includes a crash sensor **18** and a power source (not shown). The crash sensor **18** operates to complete the circuit in response to vehicle deceleration indicative of a collision. A gas flow means **28**, such as an opening in the inflator **14**, conveys gas, which is generated by combustion of the gas generating material **16**, to the vehicle occupant protection device **26**.

A preferred vehicle occupant protection device **26** is an air bag that is inflatable to help protect a vehicle occupant in the event of a collision. Other vehicle occupant protection devices that can be used with the present invention are inflatable seat belts, inflatable knee bolsters, inflatable air bags to operate knee bolsters, inflatable head liners, and inflatable side curtains.

Referring to FIG. **2**, the igniter **24** has a central axis **39** and a pair of axially projecting electrodes **40** and **42**. A heating element in the form of a bridgewire **44** is electrically connected between the electrodes **40** and **42** within the igniter **24**. An ignition material **48** is contained within the igniter **24**. The ignition material surrounds and is in contact with the bridgewire **44** so that the ignition material is in a heat receiving relationship with the bridgewire **44**.

The igniter **24** further includes a header **50**, a charge cup **52** and a casing **54**. The header **50** is a metal part, preferably made of 304L steel, with a generally cylindrical body **60** and a circular flange **62** projecting radially outward from one end of the body **60**. A cylindrical outer surface **64** of the body **60** has a recessed portion **66** defining a circumferentially extending groove **68**.

The charge cup **52** also is a metal part, and has a cylindrical side wall **70** received in a tight fit over the body **60** of the header **50**. The side wall **70** of the charge cup **52** is fixed and sealed to the body **60** of the header **50** by a circumferentially extending weld **72**. The charge cup **52** is further secured to the header **50** by a plurality of circumferentially spaced indented portions **74** of the side wall **70** that are crimped radially inward into the groove **68**. In this arrangement, the side wall **70** and a circular end wall **76** of the charge cup **52** together contain and hold the ignition material **48** in a heat transferring relationship with the bridgewire **44**. A plurality of thinned portions (not shown) of the end wall **76** function as stress risers that rupture under the influence of the combustion products generated by the ignition material **48**.

The casing **54** is a sleeve-shaped plastic part that is shrink-fitted onto the header **50** and the charge cup **52** so as to insulate and partially encapsulate those parts. An opening **79** in the casing **54** allows ignition products escaping through the ruptured thinned portions of the charge cup **52** to exit the igniter **24**.

The header **50** has a pair of cylindrical inner surfaces **80** and **82** that are axially aligned and together define a central passage **84** extending fully through the header **50**. The first electrode **40** has an inner end portion **86** extending along the entire length of the central passage **84**. A pair of axially spaced apart glass seals **88** and **90** surround the first electrode **40** in the central passage **84**, and electrically insulate the first electrode **40** from the header **50** and from the electrode **42**. Preferably, the glass seals **88** and **90** are formed from a barium alkali silicate glass. The second electrode **42** extends only partially along the length of the central passage **84** and, at one end **43**, seats against the header **50** in direct contact with the header **50**.

The bridgewire **44** extends from a radially extending surface **41** of the first electrode **40** to a radially extending surface **51** of the header **50**. The bridgewire **44** has flattened opposite end portions **100** and **102**, which are fixed to the header surface **51** and the electrode surface **41** by electrical resistance welds **104** and **106**, respectively. The opposite end portions **100** and **102** of the bridgewire **44** become flattened under the pressure applied by welding electrodes (not shown) that are used to form the resistance welds **104** and **106**. The bridgewire **44** thus has an unflattened major portion **108** extending between the opposite end portions **100** and **102**. The major portion **108** of the bridgewire **44** is bent so that the major portion **108** lies primarily in a plane spaced from the plane of the opposite end portions **100** and **102**, from a radially extending surface **89** of the first glass seal **88**, and from the header surface **51**.

The bridgewire **44**, in one embodiment, is formed from a high resistance metal alloy. A preferred metal alloy is "NICHROME", a nickel-chromium alloy. Other suitable alloys for forming a high resistance bridgewire **44** include platinum-tungsten and 304L steel. An electrical current flow in the bridgewire **44** resistively heats the bridgewire to a temperature of at least about 450° C. The heat generated by the bridgewire **44** is sufficient to ignite the ignition material **48**.

A semi-conductor bridge (SCB) may be used in place of the bridgewire **44**. A semi-conductor bridge consists of dissimilar conductive materials, such as a thick resistive film on a ceramic substrate, a thin resistive film deposited on a ceramic substrate, or a semi-conductor junction diffusion doped onto a silicon substrate. A current flow in the semi-conductor bridge heats the semi-conductor bridge to a temperature of about 250° C. to about 400° C., which is sufficient to ignite the ignition material **48**. An example of semi-conductor bridge includes a substrate that is formed of a ceramic material, such as dense alumina (Al_2O_3), beryllia (BeO), or steatite, and an alloy, such as nickel-chrome, phosphorous-chrome, or tantalum nitride, on the substrate.

In accordance with the present invention, the ignition material **48** comprises an energetic composition that deflagrates when the bridgewire **44** is heated to a temperature of at least about 450° C. By deflagrate, it is meant that the energetic composition undergoes an exothermic chemical reaction producing a vigorous evolution of heat and sparks or flame that move through the energetic Composition **48** at a speed less than the speed of sound.

The energetic composition **48** of the present invention comprises an intimate mixture of a particulate fuel and a particulate oxidizer. The particulate fuel is charcoal. The charcoal is present in the energetic composition in the form of a fine powder. The amount of charcoal in the energetic composition is that amount necessary to achieve sustained combustion of the energetic composition. A preferred amount of charcoal in the energetic composition is about 5% to about 20% by weight of the energetic composition. More preferably, the amount of charcoal in the energetic composition is about 10% to about 15% by weight of the energetic composition.

The energetic composition can also comprise a supplemental fuel. The supplemental fuel can be any particulate fuel commonly added to a gas generating material to improve ignitability and combustion properties, such as burn rate, combustion temperature, and impetus. A preferred supplemental fuel is sulfur. Examples of other supplemental fuels than can be used in the energetic composition are organic nitrogen containing fuels, such as guanidine nitrate, cyclotrimethyl enetrinitramine, cyclotetramethylenetetranitramine, cyanuric acid, and mixtures thereof.

The amount of supplemental fuel used in the energetic composition is less than the amount of charcoal powder used in the energetic composition. Preferably, the amount of supplemental fuel in the energetic composition is 0 to about 10% by weight of the energetic composition. More preferably, the amount of supplemental fuel in the energetic composition is 0 to about 5% by weight of the energetic composition.

The particulate oxidizer of the present invention is basic copper nitrate. Basic copper nitrate has the general formula $Cu(NO_3)2.3Cu(OH)_2$. The basic copper nitrate is used in the energetic composition in the form of a fine powder. The amount of basic copper nitrate in the energetic composition is that amount necessary to achieve sustained combustion of the energetic composition. A preferred amount of basic copper nitrate in the energetic composition is about 60% to about 90% by weight of the energetic composition. More preferably, the amount of basic copper nitrate in the energetic composition is about 65% to about 85% by weight of energetic composition.

The energetic composition can also include a supplemental oxidizer to improve ignitability and combustion properties, such as burn rate, combustion temperature, and impetus, of the energetic composition. A preferred supplemental oxidizer is an alkali metal nitrate, such as sodium nitrate and potassium nitrate. Examples of other oxidizers that can be used as a supplemental oxidizer in the energetic composition are inorganic salts, such as ammonium nitrate, strontium nitrate, ammonium perchlorate, and potassium perchlorate, and metal oxides, such as iron oxide, copper oxide, manganese dioxide, and molybdenum trioxide, and mixtures thereof.

The amount of supplemental oxidizer used in the energetic composition is 0 to about 20% by weight of the energetic composition. A preferred amount of supplemental oxidizer used in the energetic composition is about 0 to about 10% by weight of the energetic composition.

The energetic composition can also include other ingredients, such as process aids and non-energetic binders. Examples of these other ingredients are graphite and guar gum. The amount of these other ingredients in the energetic composition of the present invention is from 0 to about 5% by weight of the energetic composition.

One preferred energetic composition comprises, by weight of the energetic composition, about 10% charcoal, about 5% sulfur, about 85% basic copper nitrate, and less than 1% graphite. Another preferred energetic composition comprises, by weight of the energetic composition, about 10% charcoal, about 20% potassium nitrate, about 69% basic copper nitrate, and about 1% graphite. These energetic compositions are preferred because they produce a combustion product that is essentially free of caustic materials, have burn rates that are faster than black powder, and are more resistant to thermal decomposition and ignition by shock than black powder.

The energetic composition of the present invention can be prepared by ball milling the charcoal and supplemental fuel, if utilized, to form a fine powder of the charcoal and the supplemental fuel. The basic copper nitrate and supplement oxidizer, if utilized, are ball milled separately from the charcoal and supplemental fuel to form a fine powder of the basic copper nitrate and supplemental oxidizer.

The charcoal, the supplemental fuel, the basic copper nitrate and supplemental oxidizer are transferred to a Muller mixer. The charcoal, the supplemental fuel, the basic copper nitrate, and the supplemental oxidizer are mulled until an intimate mixture of the charcoal, the supplemental fuel, the basic copper nitrate and the supplemental oxidizer is formed. Water may be added to the Muller mixer during mulling to minimize dust formation, improve incorporation of the basic copper nitrate into the charcoal, and desensitize the mixture.

The mulled powder is transferred to a hydraulic press where it is consolidated into cakes by applying pressure of at least about 41.3 MPa (6000 psi) to discrete portions of the powder. The cakes are manually removed from the hydraulic press and broken into chunks by a coarse-toothed crusher. The chunks are transferred to a Corning mill. The Corning mill includes adjustable corrugated rollers that are cascaded. The chunks are crushed into coarse particles by the corrugated rollers. The coarse particles are then screened to form an energetic composition with the desired particle size.

Alternatively, the ball milled charcoal, supplemental fuel, basic copper nitrate, and supplemental oxidizer are transferred to a twin screw extruder instead of a Muller mixer. A minimal amount of water is added to the mixture in the extruder, and the mixture is compounded to form a paste suitable for extrusion. The paste is extruded through a die and cut to desired length. The extrudate is dried and then crushed to form an energetic composition with the desired particle size.

The particles of energetic composition so formed can be used as the sole component of the ignition material. When used as the sole component of the ignition material, the particles of the energetic composition are pressed into the ignition cup so that the energetic composition occupies a substantial portion of the ignition cup.

Optionally, the energetic composition can be combined with an energetic binder to form a solid mass of ignitable material. A preferred energetic binder is nitrocellulose. Examples of other energetic binders include polyethers and polyazides. The amount of energetic binder in the ignition material is that amount necessary to form a solid mass of ignition material. Preferably, the amount of energetic binder in the ignitable material is about 0 to about 40% by weight of the ignition material. The solid mass of ignition material is pressed into the ignition cup so that solid mass of ignition material occupies a substantial portion of the ignition cup.

When the igniter **24** is actuated, an actuating level of electric current is directed through the bridgewire **44** between the electrodes **40** and **42**. As the actuating level of the electric current is conducted through the bridgewire **44**, the bridgewire **44** is heated to a temperature of about 450° C. The heat is transferred directly to the ignition material **48**. The particles of ignition material adjacent to the bridgewire **44** ignite, resulting in deflagration of the ignition material. Deflagration of the ignition material produces ignition products, including heat, hot gases and hot particles. The ignition products are spewed outward from the igniter **24** and ignite the gas generating material.

EXAMPLE

The following Example illustrates the preparation of an energetic composition in accordance with the present invention. 10 mg of charcoal and 5 mg of sulfur are pulverized in a ball mill to form a uniform mixture of charcoal and sulfur. 85 milligrams of basic copper nitrate are pulverized separately from the charcoal and sulfur. The pulverized charcoal and sulfur mixture and the pulverized basic copper nitrate are transferred to a Muller mixer. About 5 ml of water are added to the Muller mixer to reduce dust formation, improve mixing, and desensitize the mixture. The mixture of charcoal, sulfur, and basic copper nitrate is mulled until an intimate mixture is formed. The mulled powder is transferred to a hydraulic press where it is consolidated into cakes by apply a pressure of about 41.3 MPa (6000 psi) to discrete portions of the powder. The cakes are manually removed from the hydraulic press and broken into chunks by a coarse-toothed crusher. The chunks are transferred to a Corning mill and crushed into coarse particles. The coarse particles are screened to form the energetic composition.

The energetic composition so formed has a burn rate greater that about 1.5 cm/sec. at 6.9 MPa. The energetic composition is also resistant to thermal decomposition and ignition by shock. Moreover, the energetic composition produces a combustion product that is essentially free of caustic materials.

From the above description of the invention, those skilled in the art will perceive improvements, changes and modifications. Such improvements, changes and modifications within the skill of the art are intended to be covered by the appended claims.

Having described the invention, the following is claimed:

1. An electrically actuatable igniter comprising:

a pair of electrodes;

a heating element electrically connected between said electrodes; and

an ignition material in contact with said heating element, said ignition material including anenergetic composition that comprises, by weight of energetic composition, about 60% to about 90% basic copper nitrate, up to about 20% supplemental oxidizer, about 5% to about 20% charcoal, and up to about 10% supplemental fuel.

2. The igniter of claim **1** wherein the supplemental fuel is sulfur.

3. The igniter of claim **1** wherein the supplemental fuel is selected from the group consisting of potassium nitrate and sodium nitrate.

4. The igniter of claim **1**, wherein the energetic composition further comprises a processing aid or a binder.

5. The igniter of claim **1**, wherein the ignition material further comprises up to about 40%, by weight of ignition material, an energetic binder.

6. The igniter of claim **5**, wherein the energetic binder is nitrocellulose.

7. An energetic composition comprising, by weight of the energetic composition, about 65% to about 85% basic copper nitrate, up to about 10% supplemental oxidizer, about 10% to about 15% charcoal, and up to about 5% supplemental fuel.

8. An energetic composition consisting essentially of basic copper nitrate, charcoal, and sulfur.

9. An energetic composition comprising, by weight of the energetic composition, about 10% charcoal, about 5% sulfur, about 85% basic copper nitrate, and less than 1% graphite.

* * * * *